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A Study of The Mechanical Analysis of Crushed Stone

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The sizing of concrete aggregates has long been a source of petty annoyance as between producers and consumers, due undoubtedly to a mutual lack of knowledge as to the other fellows' problems.

Quarry operators very generally feel that architects and engineers write specifications covering the grading of aggregates, without a proper regard for the mechanical problems involved in producing material to fill those specifications.

Fifteen years ago when specifications frequently read "the stone shall ALL be the size of a walnut" quarrymen demonstrated that they could produce very clean screened stone, graded to very narrow limits, even though they knew that the revolving circular screen lacked much of being mechanically perfect.

Of course the screens would only produce a limited amount of material conforming to such a narrow limit specification, and the disposition of sizes just a trifle larger or smaller than a walnut often presented a serious problem.

At that time engineers and architects might have been justified in asking quarrymen to devise and install some type of screen, of greater mechanical efficiency than the revolving circular screen. The present practice, requiring aggregates graded between rather wide limits, completely justifies the use of the revolving screen, but at the same time it takes the engineers and architects even farther away than before, from a proper understanding of the crusherman's problems.

Likewise the wide limits in sizes of present specifications, create in the mind of the quarryman, an idea that almost any size or combination of sizes will make good concrete.

Such a situation fully justifies the recent proposal of the A. S. T. M. that engineers, architects and producers of mineral aggregates, get together and thrash out the problem of establishing standard sizes of mineral aggregates.

It will not be a simple problem. A good architect, or a good engineer is a man of decided individuality. If he feels that 3/8 in. to 1 3/8 in. stone is the right material for his work, it is often difficult to convince him that 1/4 in. to 1 3/4 in. will serve his purpose equally well. He often overlooks the fact that if a plant is turning out a large proportion of either of those sizes, he cannot, at the same time, expect the plant to make heavy shipments of 3/4 in. to 1 in.

On the other hand, quarrymen as a rule may be justly criticised because of their neglect to fully inform themselves as to the possibilities and the limitations of their screening plants.

The problem is made more difficult because the "Rule of Thumb" must prevail to a great extent, even where the attempt is being made to be most accurate. Exact, scientific measurement is difficult.

Various materials break differently and cubes, long splinters, or flat shells are common types. A screen, producing several sizes of stone, working under 1/2 or 1/3 load, will produce all its sizes (except rejects) noticeably larger than that same screen will produce working under a normal load.

Even the personal equations of different inspectors has a decided effect in testing materials at the plant.

And yet a means must be found to enable producers and consumers to get a better understanding of the problem. It automatically divides itself under two general heads. First, what are the essential sizes of aggregates required by the consumer? Second, what are the sizes, and the proportion of each size produced by the crushing plant?

The producer is quite willing to concede that the customer is always right, and is willing to install equipment to make what the consumer wants, but the consumer must remember that simplified requirements on

his part will secure better service from the producer, and that complicated requirements must add to the cost of the material.

With these things in mind, the following study was recently made of the second part of the problem.

The material is dolomitic limestone, lying on horizontal beds, the strata from 6 to 24 in. thick, blasted so that it can be handled by steam shovels with 3½ yard dippers, and can be handled in a primary gyratory crusher having a 36 in. opening. This crusher breaks the stone to 6 in. and smaller. This product goes to a scalping screen, where it is roughly sized. This screen removes the fines, sending them to the finishing screens, and distributes the coarser stones, according to size, to five recrushing gyratories, whose product, all of which will pass a 3½ in. ring, is also sent to the finishing screens.

The finishing screens have only one duty, to separate the product into nine different primary sizes, which, according to the A. S. T. M. system of designation, are as follows:

0—¼ in., ¼—⅜ in., ⅜—½ in., ½—¾ in., ¾—1 in., 1—1½ in., 1½—2 in. 2—2½ in., 2½—3½ in.

Some of these sizes are just what the market requires. It is necessary at present to make all the other sizes, so that they may again be mixed in proportions to fill the most exacting specifications.

It would be natural to suppose that the various screen sections would always produce a regular fixed proportion of the entire product, and the crusherman, knowing these proportions, would market his product accordingly. The problem is by no means so simple. Fluctuations in the consumer's demands, compel the crusherman quite generally to recrush one or several of the primary sizes, most of the time.

A brisk demand for ¼—2 in. requires the recrushing of 2—2½ in. and 2½—3½ in. If the engineer's specification for ¼—2 in. is badly out of balance, and it often is, it may be necessary to recrush a part of the 1½—2 in. This recrushing probably will produce too much ¼—⅜ in. and ⅜—½ in., which will require that part of each of these be recrushed to 0—¼ in., which is the specification for agricultural limestone. If the demand for Agstone is good, the quarryman is glad to make that reduction, but if the 0—¼ in. is not marketable, such reduction at once adds to the cost of the ¼—2 in.

It is therefore evident that a particular system of screens does not by any means produce fixed known proportions of the various primary sizes. Consequently a combination size, such as ¼—2 in. varies continually in the gradation of its constituent sizes, and this is one reason for requiring a range in intermediate grading requirements.

The operator could make a most careful and systematic analysis of his plant, working under one set of conditions, with the very positive probability that those conditions would not generally represent normal operating conditions. Even while the test was being made, a delay in the quarry, causing a light load for a time in the crushing plant, would give inaccurate results.

Realizing the existence of such difficulties, the recent study was made. The problem divides into two parts.

First, what is normal gradation, if any, of the product of a particular system of gyratory crushers?

Second, to what extent do circular, revolving screens do the work that is expected of them, and how does their product vary under different conditions?

Two parallel tests were made to determine the normal product of the system of crushers. A single block of stone weighing 256 pounds was put through the initial crusher and recrushed in the regular way, but not put through the sizing screens. This entire sample was graded through laboratory screens, with the results shown in Fig. 1.

Right at the start, a problem presented itself which may well lead to a considerable controversy. Should the laboratory screens used have square or round openings? Such screens are invariably square for sand and all fine materials, and the square screen has often been used to grade concrete sizes of gravel. On the other hand specifications for all the larger sizes quite generally read that "the stone shall pass through a 3 in. ring and be retained on a 1 in. ring." Also circular screens are generally equipped with screen plates punched with round holes.

It was noticed that the same stones that would pass the 1 in. square opening would quite generally pass the 1¼ in. round opening, and so it was decided, until some one will come forward with a better plan, that square openings should be adopted up to and including 1 in., that this 1 in. square opening is practically equal to the 1¼ in. round opening, and that round openings be used for all larger sizes.

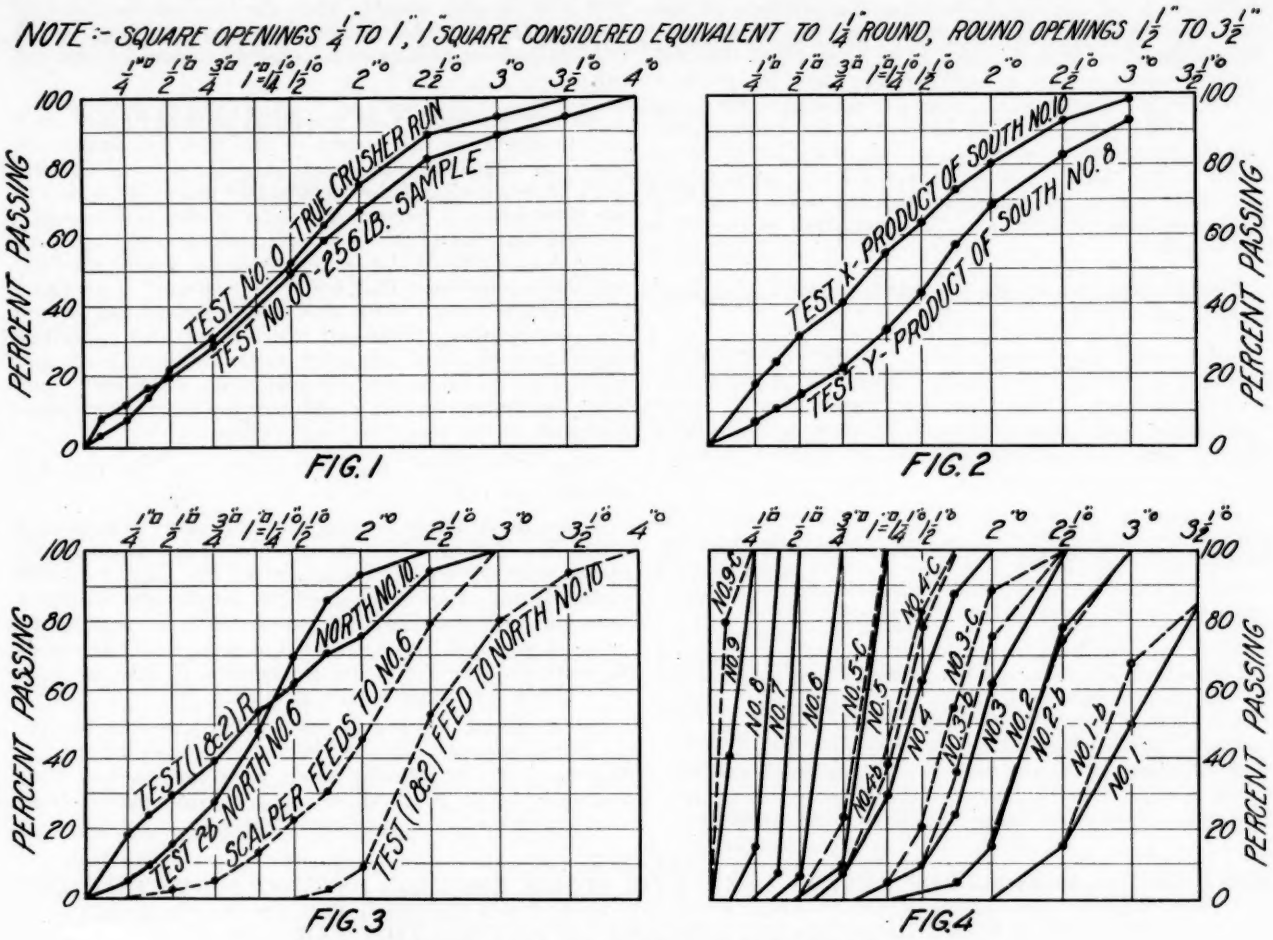
There were some limitations in the method of testing a single 256 lb. rock. It could not fill the crushers in the normal way where one stone helps to break another, and as the head swings, stones that would ordinarily be crushed, will drop through. Figure 1 shows that very clearly, between 83% and 100%.

The outstanding feature of this first study is the following general law:

> *Stone normally breaks in a system of gyratory crushers, so that the PERCENTAGE of the product passing through any screen opening, is DIRECTLY PROPORTIONAL to the SIZE of the screen opening.*

This law is stated early in this study, as all subsequest tests confirm it as a fact.

Those who are inclined to be critical may call attention to the decided flattening of chart lines between 85% and 100%. There is nothing inconsistent in that. The



MECHANICAL ANALYSIS OF CRUSHED STONE

gyratory motion of the crushing head naturally permits a few stones, just a little larger than its normal product, to drop through the crusher without being pinched.

To more closely approximate normal working conditions, 11½ tons were put through the entire plant and results carefully noted. In this test great care was taken that none of the product be lost, and that no additional stone from any outside source find its way into this test.

A world of careful preparation and careful follow up was necessary for this test, which indicates very clearly why such plant tests are not made more frequently.

From the hopper around the 36 in. crusher to the distributing boxes under each of the nine screen sections, every ledge, box, chute, or belt that the stone touched had to be carefully cleaned before the test, and as carefully policed after the test, to insure accuracy.

It is something of a job to poke 11½ tons of crushed stone through a 2 in. ring, so a method had to be devised that would get results, and yet be fairly free from criticism. Here fortune favored us and we found a way to kill two birds with one stone.

The 11½ ton sample was permitted to collect in the distributing boxes under the various screen sections, none being allowed to chute into the bins, from which cars are loaded. The stone in each box was carefully measured in a box of one cubic foot capacity, giving the percentages that had found their way through the openings of each screen section.

A screen analysis was made of the product of each of the nine screen sections.

The weighted combination of the two tests gave the screen analysis of the 11½ ton sample, the product of

the system of gyratory crushers, independent of the efficiency of the rotary screens. These results are also shown graphically in Fig. 1. It will be noted that the entire product is just a little smaller than the product of the 256 lb. sample. This is readily accounted for. The 11½ ton sample, loaded at random in the quarry, contained many pieces of rock, smaller than 256 lb. even down to the pulverized rock that always surrounds a blast hole. Also the crushers break the stone somewhat finer, under the normal load, approximated in the 11½ ton sample.

The confirmation of the general law stands out very clearly, up to 90%.

Other minor tests were made as to the product of individual crushers. The heavy rejects of the primary crusher, ranging in size from 4 in. cubes to 6 in. cubes and maybe larger, are fed by the scalping screen, into a 10 in. Fine Crushing Superior Gyratory and into a regular 16 in. gyratory.

The product of these two crushers is shown in Fig. 2. One of the intermediate sizes produced by the scalping screen, feeds into a No. 6 gyratory. This was analyzed before and after crushing and the result shown in Fig. 3.

The sizes known as 2—2½ in. and 2½—3½ in. are not always required by contractors, and when not required for shipment, are returned by conveyor belt to a second 10 in. Fine Crushing Superior Gyratory. Fig. 3 also shows this product both before and after being recrushed. These minor tests shown in Figs. 2 and 3 were all made under the normal crushing head, and here again, the product of the crushers follows the straight line rule, percentage proportional to size up to about 90%. It is also notable that the product of the two fine crushers is almost exactly the same, although material fed into one was much larger than that fed into the other.

Having determined the quantity or proportion of each size produced by the system of crushers, the next problem is to determine how effectively the screens separate the various sizes. Knowing that the revolving screen is far from being a perfect separator of the various sizes, we felt that the 11½ ton sample, which could not possibly crowd any of the screen sections, would give the maximum efficiency that could be expected from those particular screens. With that as a standard, the screen analyses resulting from half load or full load operation, would give practical efficiency ratios at those loads and enable us to state with considerable confidence, just what screen analysis we could guarantee for our product under all of the many varying conditions.

Table I gives the complete analysis of the 11½ ton sample, and Fig. 4 shows the sizes graphically.

From these data we can estimate just what screen analysis will result from the mixture of any two or more of the primary sizes. Variations in the plant load and in the degree of recrushing will, of course, give products somewhat different from those obtained by mixing the primary sizes of Table I, but it is well worth our time to work out these mixture gradations, if only to serve as a check on future screen analyses.

As we producers are in business to furnish what the market requires, I have no desire to specify what sizes the A. S. T. M. should adopt as standard, but I do feel that the A. S. T. M. should look into this problem very carefully before making a decision.

TABLE I.

MECHANICAL ANALYSIS OF 11½ TON SAMPLE OF STONE, CRUSHED BY GYRATORY CRUSHERS, SHOWING THE TEST SCREEN ANALYSIS OF THE UNSCREENED CRUSHER PRODUCT AND WAY IN WHICH REVOLVING SCREENS SEPARATED THIS SAME PRODUCT.

A. S. T. M. System of Naming Size	Local Name of Product	Per Cent of Total Product Passing Through the Designated Size of Test Screen and Retained on the Next Smaller Size													Per Cent Commercial Sizes Made by Screens
		Round Openings in Test Screens							Square Openings in Test Screens						
		4½"	3½"	3"	2½"	2"	1¾"	1½"	1¼"*=1"	¾"	½"	⅜"	¼"	1/10	
2½—3½	3½"	1.34	2.86	2.94	1.22	.04									8.4
2—2¾	2½"			2.76	7.75	1.24	.25	.22	.18						12.4
1½—2¼	2"			.17	6.54	6.28	2.75	.73	.73						17.2
¾—1¾	1½"				.30	3.50	7.90	9.58	6.54	2.58					30.4
¾—1	1"								3.06	.29	.05				3.4
½—¾	¾"									5.83	.31	.06			6.2
⅜—½	½"										9.02	.48	.10		9.6
¼—⅜	⅜"											5.49	.91		6.4
0—¼	FF												3.46	2.54	6.0
Per Cent of Test Screen Sizes made by Crushers		1.34	2.86	5.88	15.81	11.05	10.90	10.52	10.51	8.70	9.39	6.03	4.47	2.54	100.0
Cumulative Per Cent Passing Through Test Test Screens..		100.00	98.66	95.80	89.92	74.11	63.06	52.16	41.64	31.13	22.43	13.04	7.01	2.54	

*1¼ in. round considered equivalent to 1 in. square.

Comments on the Proposed Standard for Commercial Sizes of Crushed Stone and a Suggested Compromise Standard

By A. T. Goldbeck, *Director*

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National Crushed Stone Association

In the March 1, 1926 issue of The Crushed Stone Journal, the suggested specifications for commercial sizes of broken stone and broken slag for highway construction were published and the members of the Association were asked to submit their comments thereon. The Road Materials Committee of the American Society for Testing Materials having in charge the development of this standard is very anxious to have all of the producers scrutinize it very thoroughly, with particular reference to the practicability of producing, without disproportionate expense, the sizes designated.

No doubt it would be possible from a theoretical standpoint to make as many different sizes as might be desired, but the cost of production must be considered for the extra cost must ultimately be borne in full share by the consumer. Certain sizes probably are ideal for particular purposes, and if we were seeking the fulfillment of construction ideals to the exclusion of all else, our specifications would call for even more sizes than are now produced. There is a happy mean between screening perfection and inadequate screening. That mean will involve the production of just a sufficient number of sizes to serve construction needs in a thoroughly satisfactory manner, but without the numerous fine shades of difference in size often specified by different engineers for identical purposes.

A number of comments on the suggested standard have been submitted by various producers of crushed stone and these comments are presented herewith for the sake of crystalizing the ideas of others who, thus far, have not expressed their opinions.

Comments Made on Commercial Standard Sizes of Stone as Published in the March, 1926, Issue of The Crushed Stone Journal.

Producer No. 1 suggests using 0—⅝ in. instead of 0—½ in. and 0—¾ in., also ¼—⅝ in. instead of ¼—½ in. and ¼—¾ in., also ⅝—1¼ in. instead of ½—1 in. and ¾—1¼ in. This producer further suggests a 0—25 per cent tolerance rather than 0—15 per cent for the ¼—⅝ in. He also states that it would be practically impossible for smaller plants to comply with the proposed standard. With these changes the table of commercial sizes would then read as follows:

MAXIMUM PERMISSIBLE RANGE IN MECHANICAL ANALYSIS FOR EACH SIZE

(Percentage by Weight Passing Laboratory Screens)

Designated Sizes (inches)	Diameter of Circular Openings in Laboratory Screens, Inches							
	¼	⅝	1¼	1½	2	2½	3	3½
0- ¼	85-100	100	....	....	....	....	....	....
0- ⅝	15-75	95-100	100	....	....	....	....	....
¼- ⅝	0-25	95-100	100	....	....	....	....	....
¼-1½	0-5	40-75	95-100	100	....	....	....	....
¼-2	0-5	10-25	40-75	....	95-100	100	....	....
¼-2½	0-5	10-25	40-75	....	....	95-100	100	....
⅝-1¼	....	0-15	95-100	....	....	....	....	....
1¼-2½	....	....	0-15	....	25-75	95-100	100	....
2½-3½	....	....	....	....	....	0-15	25-75	95-100

Producer No. 2 only produces two sizes under 1 in. instead of five, and also calls attention to absence of ¼—1⅛ in. very largely produced in his district.

Producer No. 3 makes suggestions leading to the following table:

MAXIMUM PERMISSIBLE RANGE IN MECHANICAL ANALYSIS FOR EACH SIZE

(Percentage by Weight Passing Laboratory Screens)

Designated Sizes (inches)	Diameter of Circular Openings in Laboratory Screens, Inches								
	¼	½	¾	1	1¼	1½	2	2½	3
0- ¼	85-100	100	....	....	....	....	....	....	....
0- ½	15-75	95-100	100	....	....	....	....	....	....
0-1	15-75	....	....	95-100	100	....	....	....	....
¼- ½	0-15	95-100	100	....	....	....	....	....	....
¼-1	0-15	25-75	....	95-100	100	....	....	....	....
¼-1½	0-10	....	40-75	....	....	95-100	100	....	....
¼-2	0-10	....	....	40-75	....	....	95-100	100	....
¼-2½	0-10	....	10-25	....	40-75	....	....	95-100	100
½-1	Same as in standard								
1¼-2½	" " " "								
2½-3½	" " " "								

Producer No. 4 suggests replacing ½—1 in. with ½—1¼ in. and 1¼—2½ in. with 2—3 in.

Producer No. 5 requests a tolerance of 10 per cent instead of 5 per cent on the ¼—1¼ in., ¼—2 in., and ¼—2½ in. sizes.

Producer No. 6 believes specification to be followed literally would require additional screens and bins at an expense out of all proportion to the benefits. Would eliminate 0—½ in., ¼—½ in., and ½—1 in., or as an alternative substitute 11/16 in. for ½ in., ¾ in. and 1 in. and 5/32 for 1 in. and 1¼ in. The main idea, however, is to cut down on number of sizes. Also requests additional tolerance from 3 to 5 per cent.

Producer No. 7 believes 2 in., 1 in., ¾ in. and screenings should be sufficient.

Producer No. 8 thinks a 15 per cent tolerance is needed on upper sizes to insure that the material will be satisfactory when produced under half loaded screens, and that intermediate gradings are too wide open. Size 0—¾ in. is entirely too wide open. Also believes that sizes ¼ in. and up in some cases might be replaced by stone of larger minimum size.

Producer No. 9 thinks sizes specified satisfactory: They now produce ¼—¾ in., ⅜—1¼ in., ⅜—1½ in., ¾—2½ in., 2½—4 in.

Producer No. 10 recommends the following sizes: 0—¼ in. or ⅜ in., 0—⅝ or ¾ in., ¼—⅝ in. or ¾ in., ¼—1¼ in., ⅝—2¾ in., ¾—1¼ in., 1¼—2¾ in., 1½—3 in. or 3½ in.

Producer No. 11 sees no particular objection to proposed standard. Now makes 0—¼ in., ¼—¾ in., ¾—1¼ in., ¾—1½ in., and 1½—2¾ in. sizes.

Producer No. 12 thinks they could take care of most of the sizes except ½—1 in., for this they could furnish ½—1¼ in.

Producer No. 13 now can make 0—⅜ in., ⅜—¾ in., ¾—1¾ in., 1¾—3 in. sizes.

Producer No. 14 believes the following sizes furnish every requirement: 0—¼ in., ¼—¾ in., ¾—1¼ in., 1¼—1¾ in., and 1¾—2¼ in. as primary sizes. Also believes 2¼ in. to be the maximum size suitable for concrete roads. A 2 in. maximum size would cut down production ten per cent.

Producer No. 15 thinks it is not practical to separate stone into more than five standard sizes, and that sizes ½ in. and ¾ in. should be replaced by ⅝ in. size and that 1 in. should be eliminated.

Producer No. 16, a joint reply from four companies of Western Pennsylvania and Eastern Ohio suggest sizes as follow: 0—¼ in., 0—¾ in., ¼—⅝ in., ¼—¾ in., ¼—1¼ in., ⅝—2¾ in., ½—1 in., ⅝—1¼ in., 1¼—2¾ in., 2¾—4 or 4½ in.

Producer No. 17 now makes 0—¼ in. square mesh, ¼—¾ in. square mesh, No. 10—¼ in. square mesh, ¾—1½ in. round and 1½—2½ in. round.

Producer No. 18 suggests the following sizes: 0—½ in. round, ½—1⅛ in., 1⅛—1¾ in., 1¾—2¾ in., 2½—4 in., 3—5 in.

Producer No. 19, the New York State Crushed Stone Association, thinks five primary sizes only should be required.

Producer No. 20 makes the criticism that there is no specific requirement for the amount retained on intermediate size screens.

Discussion of the Suggested Standard and of the Comments Thus Far Received

The suggested standard as printed in the March 1, 1926, issue of the Journal is repeated below for convenience.

MAXIMUM PERMISSIBLE RANGE IN MECHANICAL ANALYSIS FOR EACH SIZE

(Percentage by weight passing laboratory screens)

Designated Sizes* (inches)	Diameter of Circular Ope nings in Laboratory Screens Inches										
	¼	½	¾	1	1¼	1½	2	2½	3	3½	4
0- ¼[a]	85-100	100	....	....	....	....	....	....	....	....	....
0- ½[a]	15-75	95-100	100	....	....	....	....	....	....	....	....
0- ¾[a]	15-75	....	95-100	100	....	....	....	....	....	....	....
¼- ½	0-15	95-100	100	....	....	....	....	....	....	....	....
¼- ¾	0-15	25-75	95-100	100	....	....	....	....	....	....	....
¼-1¼	0-5	....	40-75	....	95-100	100	....	....	....	....	....
¼-2	0-5	5-25	....	40-75	....	....	95-100	100	....	....	....
¼-2½	0-5	....	10-25	....	40-75	....	....	95-100	100	....	....
½-1	0	0-15	25-75	95-100	100	....	....	....	....	....	....
¾-1¼	....	....	0-15	25-75	95-100	100	....	....	....	....	....
1¼-2½	....	....	....	....	0-15	....	25-75	95-100	100	....	....
2½-3½[b]	....	....	....	....	....	....	....	0-15	25-75	95-100	....

a. Designated Sizes 0—¼, 0—½, and 0—¾, when used as screenings in waterbound macadam road construction shall conform to the following additional requirements: Passing No. 100-mesh sieve, 6—12%.

b. The lower limit for Designated Size 2½—3½ may be changed to 2 in. when necessary to utilize the product of a crusher producing Designated Size ¼—2 in.
The upper limit for Designated Size 2½—3½ may be changed to 4 in. in the case of very soft stone or light or porous slag.

*Note: Stone would be known commercially according to the sizes given in this column; thus, ¼ to 1¼ in. stone, ¾ to 1¼ in. stone, etc.

Table I.

Various Uses for Which the Different Grades of Stone Are Adapted.

Designated Sizes (inches)	Suggested Uses.
0—¼	Fine screenings for waterbound road construction.
0—½	Aggregate for fine graded bituminous concrete.
0—¾	Coarse screenings for waterbound macadam road construction or aggregate for bituminous concrete.
¼—½	Fine dustless screenings for bituminous road construction.
¼—¾	Coarse dustless screenings for bituminous road construction; coarse aggregate for cement concrete where the maximum size is limited to ¾ in.
¼—1¼	Coarse aggregate for coarse graded bituminous concrete; coarse aggregate for cement concrete where the maximum size is limited to 1¼ in.
¼—2	Coarse aggregate for cement concrete pavements or other concrete structures where the maximum size is limited to 2 in.
¼—2½	Coarse aggregate for cement concrete pavements or other concrete structures where the maximum size is limited to 2½ in.; as coarse aggregate for bituminous concrete base.
½—1	Commercial ¾ in. stone for bituminous road construction.
¾—1¼	Commercial 1 in. stone for bituminous road construction; binder stone for sheet asphalt, etc.
1¼—2½	Coarse aggregate for bituminous macadam penetration method and bituminous macadam base; also wearing course, waterbound macadam.
2½—3½	Coarse aggregate for bituminous macadam base or base course waterbound macadam.

It will be noted that in the above table there are five primary sizes as follows: 0—¼ in., ¼—¾ in., ¾—1¼ in., 1¼—2½ in., 2½—3½ in. A combination of the 0—¼ in. and ¼—¾ in. sizes will produce the 0—¾ in.; the ¼—1¼ in. size results by combining the ¼—¾ in. and ¾—1¼ in. and the ¼—2½ in. size may be produced by combining the ¼—¾ in., ¾—1¼ in. and 1¼—2½ in. Thus by five separations and their combinations, eight of the sizes called for may be produced. There remain the 0—½ in., the ¼—½ in., and the ½—1 in. and the ¼—2 in. sizes, requiring three extra screens, the ½ in., 1 in. and 2 in.

Referring now to the comments, thirty replies have been received and ten companies are in agreement with the proposed standards. Of the remaining twenty replies, one of which represented a group of producers in New York State and another a group of four producers in Pennsylvania and Ohio, thirteen directly or indirectly stated that the number of sizes should be reduced. Several of the members who have had long experience in quarry operations and who now operate very big plants were emphatic in their opinions that from a practical and economic standpoint it is not feasible to pro-

duce more than five primary sizes and more than this number would be an utter impossibility for the smaller operators. There are a number of different opinions as to what the different sizes should be, based for the most part on the practice in the different localities. There is also a difference of opinion as to the tolerance requirements principally on the lower sizes and in one case on the upper sizes. In some cases the intermediate grading was thought to be too wide open. Apparently from the standpoint of the economical production of stone it would be well to limit the number of standard sizes to the minimum required by standard construction. So far as can be judged from the comments thus far made it would seem desirable to limit the screening operation to separation into five primary sizes which could be combined to form other sizes required. Such sizes could be known as standard sizes and if other sizes having limited use were required in certain instances for particular purposes, these could be known as special sizes. The standard sizes, however, should include all sizes required for standard construction work.

Several suggestions have been made as to how the number of sizes might be reduced in the proposed standard by the use of screens intermediate between those now specified.

Suggested Compromise Standard

As a result of the valuable suggestions received to date and keeping in mind the size requirements for standard construction, the following compromise standard is now suggested. Unfortunately it does not meet all of the objections raised against the present standard, but this would be practically impossible.

SUGGESTED COMPROMISE STANDARD FOR COMMERCIAL SIZES OF CRUSHED STONE

MAXIMUM PERMISSIBLE RANGE IN MECHANICAL ANALYSIS FOR EACH SIZE

(Percentage by weight passing laboratory screens)

Designated Size (inches)	Diameter of Circular Opening in Laboratory Screens (inches)								
	¼	⅝	¾	1¼	1½	2	2½	3	3½
0- ¼	85-100	100	....	....	....	....	....	....	....
0- ⅝	15-75	95-100	100	....	....	....	....	....	....
¼- ⅝	0-15	95-100	100	....	....	....	....	....	....
¼-1¼	0-7.5	....	40-75	95-100	100	....	....	....	....
¼-2	0-7.5	10-25	....	40-75	....	95-100	100	....	....
¼-2½	0-7.5	....	10-25	40-75	....	....	95-100	100	....
⅝-1¼	....	0-15	....	95-100	100	....	....	....	....
1¼-2½	....	....	....	0-15	....	25-75	95-100	....	....
2½-3½	....	....	....	....	....	....	0-15	25-75	95-100

Various Uses for Which the Different Grades of Stone Are Adapted.

Designated Size (inches)	Suggested Uses
0—¼	Fine screenings for waterbound road construction.
0—⅝	Aggregate for fine graded bituminous concrete. Screenings for waterbound macadam road construction or aggregate for bituminous concrete.
¼—⅝	Dustless screenings for bituminous road construction; coarse aggregate for cement concrete where the maximum size is limited to ⅝ in.
¼—1¼	Coarse aggregate for coarse graded bituminous concrete; coarse aggregate for cement concrete where the maximum size is limited to 1¼ in.
¼—2	Coarse aggregate for cement concrete pavements or other concrete structures where the maximum size is limited to 2 in.
¼—2½	Coarse aggregate for cement concrete pavements or other concrete structures where the maximum size is limited to 2½ in.; as coarse aggregate for bituminous concrete base.
⅝—1¼	Commercial 1 in. stone for bituminous road construction; binder stone for sheet asphalt, etc.
1¼—2½	Coarse aggregate for bituminous macadam penetration method and bituminous macadam base; also wearing course, waterbound macadam.
2½—3½	Coarse aggregate for bituminous macadam base or base course waterbound macadam.

In the above standard there are five separations: 0—¼ in., ¼—⅝ in., ⅝—1¼ in., 1¼—2½ in., 2½—3½ in., and the remaining sizes could be produced from these separations with the exception of the ¼—2 in.

Whether or not this suggested compromise standard will be acceptable to the Road Materials Committee of the American Society for Testing Materials and to engineers in general, is not known. They, however, would like to have the concensus of producers' opinions and it would be well if an agreement could be reached within the industry. Write to your Bureau of Engineering, 751 Earle Building, Washington, D. C., and state your ideas regarding the desirability of the compromise standard from the producing standpoint. This seems to be the next step toward finally attaining a standard which will be acceptable, whether it be the suggested compromise or still another standard.

The President's Page

Board of Directors Will Meet in Atlantic City July 30th

Last year in Atlantic City on July 24th the Board of Directors convened for the first time in the history of the Association, except during our annual conventions. Meetings of the Executive Committee have been held from time to time, and in some years rather frequently; but the occasion never seemed to arise to necessitate calling together the Board of Directors, a body geographically unwieldy. That the importance of the Atlantic City meeting was realized was attested to by the fact that some twenty-five out of a possible thirty-five were present. Such attendance reflected the responsibility felt by the directors and their willingness to sacrifice their time during the busy season to devote their collective thought to the benefit of the Association and the industry. Out of this meeting came the establishment of the Bureau of Engineering and the transfer of our secretarial offices to Washington.

Just a year has elapsed and it now seems wise and prudent for the directors to again assemble to take account of stock, to review what has already been accomplished, and to determine upon plans and policies for our future guidance. Consequently word has gone forth calling together the directors to meet at the Hotel Ambassador, Atlantic City, Friday morning, July 30th. There are thirty-five members on the Board and we confidently expect an attendance of from twenty-five to thirty. Our directors are located from California to New Jersey, from Texas to Canada, and such an attendance will gratifyingly indicate their willingness to serve, at some personal sacrifice, our mutual interests. There are many important matters for the Board to consider, in which all of our members will be interested, and which we hope we will be able to report to you fully in the next issue of the Journal.

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1927 Convention City to Be Selected

At the coming meeting of the Board of Directors it is hoped that the time and place for the next convention may be determined, or at least that many of the cities now under consideration will be eliminated, leaving only two or three from which the Executive Committee will be asked to make a choice within a month after the meeting of the Board of Directors. Unfortunately, last year the choice of the convention city was more or less unavoidably delayed until well into October. The manufacturers comprising our associate membership are particularly desirous that an early determination of the convention city be made in order that plans for their various exhibits at this convention and others may be correlated and settled. This early determination of the convention city seems to be of more importance to them than we had realized, and it is believed that we may this year more nearly satisfy their desire in this regard.

The cities at present under consideration, each of which with its Board of Trade and hotels has earnestly sought our next convention, are Cincinnati, Detroit, Cleveland, Chicago, Buffalo, Washington, Atlantic City, Dallas, West Baden and Atlanta. Several of our members have requested us to consider Jacksonville, Fla.; Columbus, O.; and New Orleans, La. The Board of Directors will particularly welcome any advice or suggestions from members either for or against any of the cities mentioned or the suggestion of any others whose advantages we may have overlooked. Write to the President or the Secretary, or any member of the Board of Directors, and your suggestions will be given full consideration at the meeting of the Board. In general, we should select a city fairly centrally located, with hotel accommodations ample to satisfy our convention requirements, both as to comfort of attending members and meeting and exposition space, and one which also possesses some natural attractions which would tend to make the stay of the delegates pleasant and enjoyable. It is your association and in so far as you want it to succeed, we believe that it will. The Board desires your advice and we trust that you will freely express your opinion in this matter or any other.

* * * * * * * * * *

Suggestions Requested Relative to The Crushed Stone Journal and the Weekly Bulletin

We sincerely hope that the Weekly Bulletins will be interesting and helpful. There is much current information which should be promptly laid before our members without the delay necessarily incident to appearance in a monthly journal. There are also more intimate matters to be presented than should properly appear in a journal with a circulation extending beyond our own membership. Technical articles will appear from time to time in the Weekly Bulletins on matters which are not in a sufficiently advanced stage to warrant publication in the monthly journal, but are interesting as reports of progress and for indicating the present trend of events.

We believe that it will be of value to have a separate and permanent file for these Weekly Bulletins and that as time goes on they will form an interesting volume. This is equally applicable to the monthly journal, and already many articles have appeared worthy of permanent preservation.

If you have any suggestions as to how either the Journal or the Weekly Bulletins could be made more interesting or helpful, by all means write the editor, Mr. Boyd, who will be happy to have your advice.

Local Association Activities

Southwestern Division Forms Permanent Organization

A meeting of the temporary organization of the Southwestern Division of the National Crushed Stone Association was held on June 15, at the Adolphus Hotel, Dallas, Texas, for the purpose of affecting the permanent organization of this newly created division.

The meeting was attended by the following members:

M. P. Lee, Chico Stone Products Co., Dallas, Texas.

T. F. Sharp, Texas Trap Rock Corp., San Antonio, Texas.

E. Eikel, Dittlinger Lime Co., New Braunfels, Texas.

C. Westbrook, Landa Rock Products Co., New Braunfels, Texas.

Max. A. Altgelt, New Braunfels Limestone Co., New Braunfels, Texas.

A. S. Goetz, Thurber Earthen Products Co., Ft. Worth, Texas.

W. F. Wise, Stringtown Crushed Stone Co., McAlester, Okla.

There were present as guests:

J. R. Boyd, Sec'y, National Crushed Stone Ass'n, Washington, D. C.

R. J. Hank, Temporary Mgr., Southwestern Division, Austin, Texas.

W. A. Moore, Hughes Stone Co., Tulsa, Okla.

R. M. Lively, Jacksboro Crushed Stone Co., Jacksboro, Texas.

W. H. Fursman, Bromide Crushed Rock Co., Bromide, Okla.

In the absence of Colonel E. C. Dodson, temporary president, Mr. E. Eikel, temporary vice-president, presided.

After the reading and approving of the minutes of the previous meeting, Mr. Wise gave his report as temporary secretary-treasurer.

Mr. Hank, temporary manager, was then called upon for a report covering his activities during the last two months and for his recommendations to the permanent organization. He emphasized the desirability of cooperating with the various highway departments and engineers in an effort to reduce to a minimum the various sizes of stone and to obtain a uniform system of gradation of the intermediate sizes. In concluding his remarks, emphasis was placed upon the necessity of conducting the affairs of the Division on a high moral and ethical plane if the respect and consideration of the users of our product are to be enjoyed.

Mr. Boyd, Secretary of the National Association, was then asked for suggestions as to forming the permanent organization and for a general discussion of the National Association. After expressing his pleasure at being able to meet with the Southwestern producers on the occasion of the establishment of their permanent organization, he assured them that the National Association is in hearty accord with this movement and wishes to lend its assistance in every way possible. The desirability of the Southwestern Division's working in harmony with the National Association was pointed out and in order that this might better be accomplished, it was suggested that all members of the Southwestern Division should also hold membership in the National organization. The procedure followed by other local associations in establishing their permanent organizations was outlined.

In speaking of The Crushed Stone Journal and the Weekly Bulletin, members were urged to submit their criticisms and suggestions to the Editor in order that these publications of the Association may be made of the greatest possible value to the members.

Mr. Boyd brought to the attention of the meeting Docket Bulletin 355 of the Southwestern Freight Bureau in which there are proposed certain changes in the tariff which would place an undue hardship on the producers in Southwestern Freight Bureau Territory. He stated that the National Association, on behalf of the Southwestern producers, has entered formal protest opposing these changes and that it is now necessary for every interested producer to submit in writing to the Secretary's Office at Washington their specific reasons for their opposition in order that a comprehensive statement may be prepared and presented to the Southwestern Freight Bureau when this matter comes up for hearing.

In closing his remarks, Mr. Boyd again emphasized the desirability of the two organizations working in close harmony and stated that although the Southwestern Division is separated by many miles from the headquarters of the National Association, it is the sincere desire of the National Association to cooperate with the Southwestern Division in every way possible to the end that the best interests of the crushed stone industry in the Southwest may be ethically and expeditiously advanced.

Following Mr. Boyd's remarks, the chair was instructed, upon motion of Mr. Wise, seconded by Mr. Goetz, that proper resolution be prepared and sent to Col. Dodson expressing sympathy for him in his present illness.

It was then moved by Mr. Lee and seconded by Mr. Goetz that the temporary organization be disbanded and that the Chair proceed with the formation of the permanent organization.

The following were then elected as officers of the Southwestern Division of the National Crushed Stone Association:

OFFICERS

PRESIDENT, W. F. WISE, STRINGTOWN CRUSHED STONE CO., *McAlester, Okla.*

VICE-PRESIDENT, E. EIKEL, DITTLINGER LIME CO., *New Braunfels, Texas.*

TREASURER, C. WESTBROOK, LANDA ROCK PRODUCTS CO., *New Braunfels, Texas.*

The Board of Directors and Executive Committee are as follows:

BOARD OF DIRECTORS

E. EIKEL, DITTLINGER LIME CO., *New Braunfels, Texas.*

A. S. GOETZ, THURBER EARTHEN PRODUCTS CO., *Ft. Worth, Texas.*

E. C. DODSON, CHICO STONE PRODUCTS CO., *Dallas, Texas.*

C. WESTBROOK, LANDA ROCK PRODUCTS CO., *New Braunfels, Texas.*

MAX A. ALTGELT, NEW BRAUNFELS LIMESTONE CO., *New Braunfels, Texas.*

W. F. WISE, STRINGTOWN CRUSHED STONE CO., *McAlester, Okla.*

R. M. LIVELY, JACKSBORO CRUSHED STONE CO., *Jacksboro, Texas.*

W. H. FURSMAN, BROMIDE CRUSHED STONE CO., *Bromide, Okla.*

T. F. SHARP, TEXAS TRAP ROCK CORP., *San Antonio, Texas.*

EXECUTIVE COMMITTEE

A. S. GOETZ, THURBER EARTHEN PRODUCTS CO., *Ft. Worth, Texas.*

E. C. DODSON, CHICO STONE PRODUCTS CO., *Dallas, Texas.*

W. H. FURSMAN, BROMIDE CRUSHED STONE CO., *Bromide, Okla.*

W. F. WISE, STRINGTOWN CRUSHED STONE CO., *McAlester, Okla.*

E. EIKEL, DITTLINGER LIME CO., *New Braunfels, Texas.*

On motion of Mr. Goetz, seconded by Mr. Eikel, the Chair was authorized to appoint a Committee on Constitution and By-Laws with instructions to draft same for later consideration of the meeting. Messrs. Lee, Eikel and Boyd were appointed on this committee. The meeting then adjourned for luncheon, after which the report of the committee on Constitution and By-Laws was submitted by Chairman Lee. After considerable discussion and a few changes the Constitution and By-Laws were adopted on motion of Mr. Goetz, seconded by Mr. Eikel.

On motion made by Mr. Eikel, seconded by Mr. Lively, the President was instructed to prepare suitable resolution to be sent to the National Crushed Stone Association, thanking them for sending Mr. Boyd to attend the meeting and assisting in the organization of the Southwestern Division.

It was decided to retain Mr. R. J. Hank as Secretary-Manager with headquarters at Austin, Texas.

The meeting was then thrown open for general discussion. The advisability of all members of the Southwestern Division joining the National Association was brought up and as a result all of those present who were not members of the National organization took out membership.

The meeting then adjourned.

New York State Crushed Stone Association

The regular monthly meeting of the New York State Crushed Stone Association was held at the Barnes Hotel, Amsterdam, N. Y., on Friday, June 25th with eighteen members present.

The morning was devoted to a motor trip to the Cushing Stone Company plant at South Amsterdam where a very lucrative hour was spent in an inspection trip through the quarry and mill. Led by Mr. J. E. Cushing the members viewed a high class operation producing a very acceptable quality of limestone and remarks were heard in commendation of Mr. Cushing's successful efforts in developing so favorable a plant which delivers via both rail and water.

Following the inspection trip, the party motored to the Antlers' Club, an unusually attractive spot overlooking the Mohawk River about four miles west of the city. Here a very enjoyable luncheon was served after which President Seitz called the assemblage to order for a business meeting. After the reading and approving of the minutes, on motion of Mr. Owens, seconded by Mr. McGrew, the following report was adopted, with instructions to send copy of same to Mr. Goldbeck, Director of the Bureau of Engineering, of the National Association.

"We have considered the matter of proposed standard sizes of crushed stone referred to us at the last meeting of the Association and recommend that no series of standard sizes be adopted except such as can be produced by the use of screens having not to exceed a total of five sizes of screen openings.

Respectfully submitted,

W. L. SPORBORG,
JAMES SAVAGE,
Committee."

The question of the adoption of an emblem for the Association was next taken up. The Secretary exhibited a cut kindly prepared by Editor Rockwood of Rock Products, Chicago. After considerable discussion Mr. Cushing moved, and Mr. Hunter supported the motion, that the emblem be adopted as presented with but the elimination of the New York State outline in the background. Carried. It was further moved and carried that the Secretary procure one or more for each member, cost to be assessed against the respective individual or firm.

Mr. McGrew then made an eloquent appeal to hold the July meeting at Utica, stressing the fact that there were more individual companies in this locality than anywhere else, and a diversified program of interest could easily be arranged. Mr. Sporborg moved that we meet at Utica in

July and the officers be empowered to arrange necessary details. Seconded by Mr. Cushing. Carried.

President Seitz spoke on the advantage of having prearranged programs for the meetings and again urged increased attendance and more active interest by each member.

After thanking the host, Mr. Cushing, for his efforts and courtesy in arranging such a satisfactory meeting, the adjournment resolution was passed at 4:50 P. M.

Ohio Crushed Stone Association

The regular monthly meeting of the Governing Board of the Ohio Crushed Stone Association was held at the offices of the Association at Columbus on June 10, 1926, with E. E. Evans, President, presiding.

The following members were present:

E. E. Evans, Whitehouse Stone Co., Toledo, O.
C. L. McAllister, Supply Distributors Corp., Cleveland, O.
H. M. Sharp, France Stone Co., Toledo, O.
H. E. Bair, France Stone Co., Toledo, O.
O. A. Scott, Bluffton-Lewisburg Co., Findlay, O.
F. E. Miller, Standard Slag Co., Youngstown, O.
R. Sinclair, The Barrett Co., Columbus, O.
W. A. Stelzer, France Stone Co., Urbana, O.
B. T. Van Camp, Van Camp Stone Co., Cincinnati, O.
H. D. Van Camp, Van Camp Stone Co., Cincinnati, O.
Carl L. Van Voorhis.

After the reading and approving of the minutes, the report of the Engineering Committee was heard, giving the results of a conference held on May 14th with Engineers Schlesinger, Kirk, Moyer, Carr and Perry. The Committee was of the opinion that the results of the conference were very satisfactory.

The general letter which went out under date of June 1st, relative to the calking of cars with excelsior and other foreign materials which may get into road building aggregates was discussed and the members all expressed themselves as being willing to cooperate to the fullest extent with the Highway Department in remedying this bad practice.

Mr. Strang, who is in charge of publicity, met with the board and outlined some of his ideas to them and solicited their cooperation in the furnishing of items of interest which they and their salesmen might be able to send in relative to work in their various territories and which might be woven into a story which the newspapers would publish and in which the reading public would be interested.

The question of a new design or cross-section for a macadam pavement was discussed and efforts will be made to try to get the Highway Department to approve of some construction along the lines of the design suggested by the Association's Engineer, Mr. Van Voorhis.

The question of advertising for "Better Highways" magazine was discussed and the suggestion of Mr. Bair was adopted that a letter go forward to the members relative to this matter.

On motion of Mr. Scott, seconded by B. T. Van Camp, the meeting was adjourned.

The CRUSHED STONE JOURNAL

J. R. BOYD, Editor

A. T. GOLDBECK, Director, Bureau of Engineeering

The National Crushed Stone Association

OFFICERS

OTHO M. GRAVES President
Drake Building
Easton, Pa.

J. R. BOYD, Secretary

JAMES SAVAGE, Treasurer

REGIONAL VICE-PRESIDENTS

A. R. Wilson, (Western) G. J. Whelan, (Central) Stirling Tomkins (Eastern)
Thomas McCroskey, (Southern) W. R. Sanborn, (Northern)
C. M. Doolittle, (Canadian)

EXECUTIVE COMMITTEE

O. M. GRAVES, Chairman

H. E. Bair	F. R. Kanengeiser	F. W. Schmidt
W. Scott Eames	E. J. Krause	W. L. Sporborg

EX-PRESIDENTS

A. J. Blair	John Rice	E. J. Krause
W. Scott Eames	F. W. Schmidt	J. J. Sloan

SAFETY!

Safety, or more specifically interpreted, the protection of life and property, is a factor in the industrial development of today upon which too much emphasis cannot be placed.

The stupendous demands made upon modern industry have given rise to a phenomenal development in the processes of manufacture. Speed and mass production have forced us to develop machinery to perform most of the operations previously accomplished by hand. With the advent of machinery, the industrial accident hazard has increased many-fold and yet we have been so intensively engaged in the business of producing, that it is only within comparatively recent years that we have begun to study the ways and means by which the industrial worker might be better protected from the increased hazards of our modernized methods.

The question of safety as applied to the quarry industry is one which merits the careful and serious consideration of everyone engaged in the production of crushed stone. When it is realized that approximately $400,000 per year is paid as compensation for fatal accidents occurring in the quarry industry, exclusive of the costs of medical attention and compensation for lost wages in cases of non-fatal injuries, it is seen that there is still much to be done.

This fact is further emphasized by a table recently released by the Bureau of Mines which shows the relative standing of all companies in the quarry and open-pit class entered in the 1925 National Safety Competition. Companies are tabulated according to their accident-severity rate, which is the number of days of disability from accidents per thousand man-hours of work. The accident-frequency rate is also given which represents

ENTRY APPLICATION

Director, Bureau of Mines,
Department of Commerce,
Washington, D. C.

SUBJECT: National Safety Competition.

Dear Sir:

This company desires to enter the National Safety Competition for the EXPLOSIVES ENGINEER safety trophy. A complete record of each accident in 1926 disabling an employee longer than the remainder of the day of the accident will be forwarded to your office. Each report will show the number of calendar days of disability of the injured employee and date of employee's return to duty. At the close of each month the number of employees and time worked will be reported. The number of men regularly employed is approximately men underground in the mine or men in the quarry pit or open-pit mine. The identity of the property for which accident reports will be furnished is indicated below.

Very truly yours,

.....Company

.....Signature

.....Title

Name of underground mine.....

Name of quarry or open-pit mine.....

Location: State.....County.....P. O.....

Kind of mineral or stone produced.....

(Note--Carbon copies of regular forms prescribed by Compensation Commission of your State may be used in furnishing the accident data required for the contest; or, if you desire, the Bureau will furnish suitable forms. Director, Bureau of Mines.)

ELIGIBILITY REQUIREMENT

2. Those eligible to compete for the Trophies are companies operating a coal mine employing 50 or more men underground, a metal or other mine employing 50 or more men underground, or a quarry or open-pit mine employing 25 or more men in the pit. Because of the limited amount of office help available in the Bureau at present, the contest during 1926 will be limited to the 600 mines and quarries meeting the above requirements, who first notify the Bureau of Mines of their intention to regularly report the necessary information. A separate award will be made to the winner in each of these three groups.

the number of lost time accidents per million man-hours of work.

The accident-severity rate varied from zero for the first seven companies to a maximum of 64.621, while the accident-frequency rate varied from zero for the first seven companies to a maximum of 94.003. The wide variation between the maximum and minimum values of these two rates, clearly indicates that the crushed stone industry should take an active interest in industrial accident prevention.

For this Association to undertake to compile and analyze comprehensive and accurate accident statistics would entail a trained personnel and a considerable outlay of funds. This, however, is not necessary provided all of our members who are eligible, enter The National Safety Competition. This contest, as most of you undoubtedly know, was inaugurated in 1925 by the Explosives Engineer and is held under the auspices of the United States Bureau of Mines. This arrangement places at the disposal of the industry the expert statisticians of the Bureau of Mines and it would certainly seem that it is incumbent upon us to take full advantage of this opportunity.

The information gathered by the Bureau as a result of The National Safety Competition will be a source of valuable information to the industry, as it makes it possible to conduct intensive studies which yield information not otherwise obtainable. From these intensive studies can be determined the types of accidents most prevalent and the best means of preventing them, as well as information which will ultimately lead to a reduction in insurance premiums.

The Portland Cement Association was quick to see the advantages to be gained by participating in this contest as in 1925 approximately 100% of their membership entered. The National Crushed Stone Association was conspicuous by the absence of its members, as not more than a very small percentage of our companies competed.

Entries for the 1926 National Safety Competition will not be received later than July 31, and it therefore behooves every eligible company to fill out the enclosed application blank and immediately send it to the Bureau of Mines. We earnestly request your whole-hearted cooperation in this matter, so please do not delay.

Active Members of the National Crushed Stone Association

No Memberships	
2	Acme Limestone Co., Alderson, W. Va.
2	Albany Crushed Stone Co., 55 State St., Albany, N. Y.
1	Max A. Altgelt, New Braunfels, Texas.
1	American Crushed Rock Co., Ostrander, Ohio.
2	American Lime and Stone Co., Bellefonte, Pa.
1	American Stone Ballast Co., High Bridge, Ky.
1	Anna Stone Company, Anna, Ill.
2	Ashland Limestone Co., 408 Ashland National Bank Bldg., Ashland, Ky.
2	The Edward Balf Company, 14 Haynes St., Hartford, Conn.
1	Beachville White Lime Co., Beachville, Ont., Canada.
1	C. C. Beam, Melvin, Ohio.
1	Belmont-Gurnee Stone Co., North Bergen, N. J.
10	Bessemer Limestone & Cement Co., 714 Stambaugh Bldg., Youngstown, Ohio.
1	O. H. Binns, Logansport, Ind.
2	Blake Brothers Co., 204 Balboa Bldg., San Francisco, Calif.
2	Blue Ridge Stone Co., Roanoke, Va.
5	Bluffton-Lewisburg Stone Co., Findlay, Ohio.
2	Boggs, Burnam & Co., Richmond, Ky.
4	Bound Brook Crushed Stone Co., Bound Brook, N. J.
1	Britton Crushed Stone Corp., 717 Commerce Bldg., Rochester, N. Y.
1	Bromide Crushed Rock Co., Bromide, Okla.
6	Brownell Improvement Co., 1220 Chamber of Commerce Bldg., Chicago, Ill.
6	Buffalo Cement Co., 110 Franklin St., Buffalo, N. Y.
8	Buffalo Crushed Stone Co., 1048 Ellicott Square, Buffalo, N. Y.
2	Callanan Road Improvement Co., P. O. Box 773, Albany, N. Y.
2	Harry T. Campbell Sons Co., Inc., Towson, Md.
4	Canada Crushed Stone Corporation, Hamilton, Ont., Canada.
5	Carbon Limestone Co., 814 Stambaugh Bldg., Youngstown, Ohio.
1	Carolina Road Granite Co., 606 S. Michigan Ave., Chicago, Ill.
1	Carthage Crushed Limestone Co., P. O. Box 409, Carthage, Mo.
4	Casparis Stone Co., 302 Yuster Bldg., Columbus, Ohio.
1	The Casper Stolle Quarry & Contracting Co., 503 First National Bank Bldg., East St. Louis, Ill.
1	Cerulean Stone Co., Cerulean, Ky.
2	Chickamauga Quarry & Const. Co., 1st Nat'l Bank Bldg., Chattanooga, Tenn.
2	Chico Stone Products Co., 404 Santa Fe Bldg., Dallas, Texas.
1	Clayton Contracting Co., 3800 W. Pine Blvd., St. Louis, Mo.
1	The Collins Granite Co., Inc., R. F. D. No. 4, Danville, Va.
6	Columbia Quarry Co., 910 Century Bldg., St. Louis, Mo.
2	Commonwealth Quarry Co., Summit, N. J.
2	The F. E. Conley Stone Co., 253 Union Station, Utica, N. Y.
10	Connecticut Quarries Co., New Haven, Conn.
2	Consolidated Stone & Sand Co., Clare Road, Montclair Heights, Essex County, N. J.
3	Consumers Company, 111 W. Washington St., Chicago, Ill.
2	Cushing Stone Co., Inc., 437 State St., Schenectady, N. Y.
2	Davis Bros. Stone Co., Lannon, Wis.
2	Delaware River Quarry & Construction Co., 21 Bridge St., Lambertville, N. J.
4	Dittlinger Lime Co., New Braunfels, Tex.
1	Dolese Bros. Co., 337 West Madison St., Chicago, Ill.
2	Dolese & Shepard, 108 South LaSalle St., Chicago, Ill.
2	Dolomite Products Co., 124 E. & B. Bldg., Rochester, N. Y.
2	Duluth Crushed Stone Co., 1506 Alworth Bldg., Duluth, Minn.
4	John T Dyer Quarry Co., Harrison Block, Philadelphia, Pa.
1	Dubuque Stone Products Co., Dubuque, Iowa.
1	East St. Louis Stone Co., 255 Arcade Bldg., East St. Louis, Ill
4	Elmhurst-Chicago Stone Co., Elmhurst, Ill.
1	Eyermann Construction Co., 1210 S. Grand Blvd., St. Louis, Mo.
1	Fay Quarries, 101 Union St., New Bedford, Mass.
1	Federal Stone Co., 133 West Washington St., Chicago, Ill.
11	France Stone Co., 1800 2nd National Bank Bldg., Toledo, Ohio.
3	Franklin Limestone Co., 612 10th Ave. N., Nashville, Tenn.

12 General Crushed Stone Co., Drake Bldg., Easton, Pa.
2 Genessee Stone Products Co., Batavia, N. Y.
2 Gopher Stone Co., 1500 Johnson St., N. E., Minneapolis, Minn.
1 Gordon Crushed Stone Co., 18 Toronto St., Toronto, Canada.
4 Granite Rock Co., Box M, Watsonville, Calif.
2 Great Notch Corporation, 20 Washington Place, Newark, N. J.
2 Greenville Stone & Gravel Co., 269 Walnut St., Memphis, Tenn.
1 Grove City Limestone Co., Sharon, Pa.

2 Hagersville Contracting Co., Ltd., Hagersville, Ontario, Canada.
3 Hagersville Quarries, Ltd., 4 Flora St., St. Thomas, Ont., Canada.
2 Harris Granite Quarries Co., Salisbury, N. C.
4 Edward Hely Stone Co., Cape Girardeau, Mo.
1 Holston Quarry Co., Robbins Bldg., Box 292, Knoxville, Tenn.
2 T. C. Hubbert & Co., Inc., 707 S. Broome St., Wilmington, Del.
1 Hughes Stone Co., 808 Mayo Bldg., Tulsa, Okla.
1 Chas. O. Hunsicker, Hunsicker Bldg., Allentown, Pa.

4 Interstate Crushed Stone Co., P. O. Box 129, Springfield, N. J.

1 Jacksboro Stone Products Co., Jacksboro, Texas.
1 Johnson, E. B., Adams & Duford Co., Chaumont, N. Y.

10 Kelley Island Lime & Transport Co., 1125 Leader-News Bldg., Cleveland, Ohio.
3 Kentucky River Stone & Sand Co., Lawrenceburg, Ky.
1 Kentucky Rock Asphalt Co., Marion E. Taylor Bldg., Louisville, Ky.
2 Keystone Trappe Rock Co., Glenmore, Pa.
2 John T. Kilcourse, 70 Belknap St., Lawrence, Mass.
2 Kittanning Limestone Co., Safe Deposit Bldg., Kittanning, Pa.

3 Lake Erie Limestone Co., 901 Wick Bldg., Youngstown, Ohio.
2 Lake Shore Stone Co., 600 Canal St., Milwaukee, Wis.
2 Lambertville Stone Quarry Co., Colonial Trust Bldg., Philadelphia, Pa.
2 Landa Rock Products Co., New Braunfels, Tex.
4 John S. Lane & Son, Inc., Meriden, Conn.
2 Lawrence Stone & Gravel Co., 516 Commercial Bank Bldg., Raleigh, N. C.
4 Lehigh Stone Co., Kankakee, Ill.
3 LeRoy Lime & Crushed Stone Corp., LeRoy, N. Y.
2 Liberty Lime & Stone Co., Rocky Point, Va.
2 Ligonier Stone Products Co., Blairsville, Pa.
4 Linwood Cement Co., 714 Kahl Bldg., Davenport, Iowa.
1 L. & M. Stone Co., Mayro Bldg., Utica, N. Y.
5 Louisville Cement Co., 315 Guthrie St., Louisville, Ky.
1 Lutz Stone Company, Oshkosh, Wis.
10 Marble Cliff Quarries Co., 907 Hartman Bldg., Columbus, Ohio.

1 Mayville White Lime Co., Mayville, Wis.
5 Thos. McCroskey, Box 262, Knoxville, Tenn.
2 Joseph McCormick, 319 Taunton Ave., East Providence, R. I.
1 W. E. McNasser, Solvay Process Co., Syracuse, N. Y.
2 Mid-West Crushed Stone Co., 514 Traction Terminal Bldg., Indianapolis, Ind.
2 Mississippi Lime and Material Co., 201 W. 3rd St., Alton, Ill.
1 Molder Bros., 810 Wilson St., Findlay, Ohio.
5 Monon Crushed Stone Co., Box 366, Monon, Ind.
1 Montreal Crushed Stone Co., 590 Union Ave., Montreal, Canada.
4 Morris County Crushed Stone Co., 17 South St., Morristown, N. J.
5 T. K. Morris Lime & Limestone Co., 2215 Oliver Bldg., Pittsburgh, Pa.
1 T. A. Morrison & Co., Ltd., 1070 Bleury St., Montreal, Canada.

1 National Lime & Stone Co., Carey, Ohio.
1 National Quarries Co., Carey, Ohio.
2 National Stone Company, Box 832, Joliet, Ill.
2 New Castle Lime & Stone Co., 500 Greer Bldg., New Castle, Pa.
10 New Haven Trap Rock Co., 67 Church St., New Haven, Conn.
1 Northwestern Quarry Co., Rapid City, S. D.
2 Norton Stone & Lime Corp., Arkay Bldg., Albany, N. Y.

5 The Ohio Marble Co., Piqua, Ohio.
2 Old Colony Crushed Stone Co., Quincy, Mass.
3 A. C. O'Laughlin Co., 131 N. Homan Ave., Chicago, Ill.

2 Peerless Quarries, Inc., 404 Court St., Utica, N. Y.
2 Pembroke Limestone Corporation, Pembroke, Va.
1 A. Petrillo Co., 5 Edgemoore Road, Wilmington, Del.
4 Piedmont Corporation, Bona Allen Bldg., Atlanta, Ga.
2 Pounding Mill Quarry, Pounding Mill, Va.
1 Edmund Putnam, Box 852, Pittsfield, Mass.

2 Quartzite Quarries, Inc., Luverne, Minn.

2 Raleigh Granite Co., Raleigh, N. C.
1 Reinhold & Co., Inc., 1422 Oliver Bldg., Pittsburgh, Pa.
12 Rock Cut Stone Co., 531 Union Bldg., Syracuse, N. Y.
2 Rock Hill Quarry & Const. Co., 1026 Title Guaranty Bldg., St. Louis, Mo.
1 Tayloe Rogers, Radford Limestone Corp., 1st Nat'l Bank Bldg., Roanoke, Va.
1 Rowe Contracting Co., Malden, Mass.

2 Saluda Crushed Stone Co., 214 Capers Bldg., Greenville, S. C.
1 J. D Sargent, Mt. Airy, N. C.
2 Schumacher Stone Co., Pandora, Ohio.
1 Skrainka Const. Co., 806 Security Bldg., 4th and Locust Sts., St. Louis, Mo.
2 Leatham D. Smith Stone Co., Sturgeon Bay, Wis.
1 Southern Mineral Co., 523 Gravier St., New Orleans, La.
1 Southern Crushed Stone & Granite Co., R.. F. D., Trenton, S. C.
2 Sowerbutt Quarries, Paterson, N. J.
1 Spartanburg Quarries Corp., 139½ E. Main St., Spartanburg, S. C.
2 T. W Spinks Co., Covington, Ky.
2 Stringtown Crushed Rock Co., McAlester, Okla.
1 Thomas Sullivan, 1042 Omaha Nat'l Bank Bldg., Omaha, Nebr.
1 Sunlight Crushed Stone Co., Madisonville, Ky.
1 Superior Stone Co., 5 N. La Salle St., Chicago, Ill.
1 The Supply Distributors Corp., Marion Bldg., Cleveland, Ohio.
2 Susquehanna Stone Co., 1007 Franklin St. Williamsport, Pa.
1 The Tarbox-McCall Stone Co., 852 Weston Ave., Findlay, Ohio.
2 Templeton Limestone Co., Kittanning, Pa.
2 Texas Trap Rock Co., 610 Maverick Bldg., San Antonia, Tex.
1 Thomas & Frankenbery, Canon City, Colo.
2 Thurber Earthen Products Co., 1701 F. & M. Bank Bldg., P. O. Box 1868, Ft. Worth, Tex.

1 The Toledo Stone & Glass Sand Co., R. R., Sylvania, Ohio.
10 Tomkins Cove Co., Tomkins Cove, N. Y.
2 Trap Rock Company, Minneapolis, Minn.
1 Jas. C. Travilla, Pilot Knob Ore Co., 211 N. 7th St., St. Louis, Mo.
5 R. B. Tyler Co., 114 Fourth St., Louisville, Ky.
2 Union Rock Co., 1403 East 16th St., Los Angeles, Calif.
2 Universal Granite Quarries Co., 133 W. Washington St., Chicago, Ill.
2 F. R. Upton, Inc., 821 Union Bldg., Newark, N. J.
2 Van Camp Stone Co., 12 E. 6th St., Cincinnati, Ohio.
1 Virginia Limestone Corp., 505 Mt. Trust Bldg., Roanoke, Va.
4 Wagner Quarries Co., Schmidt Bldg., Sandusky. Ohio.
2 Waterstreet Trap Rock Co., Water Street, Pa.
2 Waukesha Lime & Stone Co., Waukesha, Wis.
1 Welden Springs Quarry Co., Inc., Welden Springs, Mo.
1 Wentworth Quarries, Ltd., Vinemount, P. O., Ontario, Canada.
2 Western Lime & Cement Co., Milwaukee, Wis.
4 The Weston & Brooker Co., Columbia, S. C.
1 Whitehouse Stone Co., Spitzer Bldg., Toledo, Ohio.
2 Wickwire Spencer Steel Corp., Station B, Buffalo, N. Y.
2 Wing & Evans, 40 Rector St., New York, N. Y.
2 Winston & Co., Inc., Masonic Bldg., Harrisburg, Pa.
5 Wisconsin Granite Co. 105 W. Monroe St., Chicago, Ill.
1 Wood County Stone & Const. Co., Bowling Green, Ohio.
2 Woodville Lime Products Co., 622 Madison Ave., Toledo, Ohio.
2 John Wunder Co., Broadway and K Sts., Minneapolis, Minn.
2 York Hill Trap Rock Quarry Co., 98 State St., Meriden, Conn.

Associate Members of the National Crushed Stone Association

Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Crushing Plants and Machinery.

American Manganese Steel Co., Chicago Heights, Ill.
"Amsco" Manganese Steel Castings.

Armstrong Manufacturing Co., Waterloo, Iowa.
Blast Hole Drills, Bit Dressing Machines.

Atlas Powder Co., Wilmington, Del.
Explosives and Blasting Accessories.

Austin Mfg. Company, 400 N. Michigan Ave., Chicago, Ill.
Rock Crushing Machinery.

Earle C. Bacon, Inc., 26 Cortlandt St., New York City.
Complete Plants, Crushers, Elevators, Screens, Conveyors.

The Barrett Company, 40 Rector St., New York City.
Tarvia for Road Construction, Repair and Maintenance.

Blaw-Knox Co., P. O. Box 915, Pittsburgh, Pa.
Manufacturers of Steel Products.

The Browning Crane Co., 16226 Waterloo Rd. N. E., Cleveland, Ohio.
Locomotive Cranes.

C. G. Buchanan Co., Inc., 90 West St., New York City.
Crushers, Crushing Rolls, Magnetic Separators.

The Bucyrus Company, South Milwaukee, Wis.
Steam, Electric, "Diesel and Gas Shovel," Dredges.

Buffalo Wire Works, 521 Terrace, Buffalo, N. Y.
Wire Cloth and Screens.

Burrell Engineering & Construction Co., 513 West Jackson Blvd. Chicago, Ill.
Design and Construction.

Canadian Explosives, Limited, Canada Cement Bldg., Montreal, Can.
Explosives and Blasting Supplies.

Canadian Westinghouse, Ltd., Hamilton, Ontario, Canada.
Cranes, Motors, etc.

The Carroll Chain Co., 265 Hosack St., Columbus, Ohio.
"Carroll" Solid Weld Steam Shovel Hoisting Chains.

Cement Mill and Quarry, 542 Monadnock Block, Chicago, Ill.
"Publishers."

Cincinnati Rubber Mfg. Co., Cincinnati, Ohio.
Conveyor and Transmission Belting, Suction Hose, Dredging Sleeves.

The Columbus McKinnon Chain Co., 5th and Merrith Sts., Columbus, Ohio.
Hercules Solid Weld Steam Shovel Chain.

The R. & J. Dick Co., Passaic, N. J.
"Dickbelt," for Transmission, Elevating and Conveying.

E. I. du Pont de Nemours & Co., Wilmington, Del.
"Explosives of All Kinds and Blasting Accessories."

Easton Car and Construction Co., Easton, Pa.
Quarry Cars.

Ensign-Bickford Co., Simsbury, Conn.
Safety Fuse and Cordeau Bickford Detonating Fuse.

Fairbanks, Morse & Co., 347 W. 4th St., Cincinnati, Ohio.
Diesel Engines, Electric Motors.

Fate-Root-Heath Co., Plymouth, Ohio.
"Plymouth" Gasoline Locomotives.

Flexible Steel Lacing Co., 4607 Lexington St., Chicago, Ill.
Alligator and Flexco H. D. Belt Fasteners.

Frog, Switch & Mfg. Co., Carlisle, Pa.
Manganese Steel Castings.

General Electric Co., Schenectady, N. Y.
Electrical Apparatus and Supplies.

Gill Rock Drill Co., Lebanon, Pa.
Blast Hole Drilling and Fishing Tools.

The Goodyear Tire and Rubber Co., Inc., Akron, Ohio.
Belting: Transmission, Conveyor, Elevator; Hose, Packing.

Graham Coal Co., Commercial Trust Bldg., Philadelphia, Pa.
Coal.

Grasselli Powder Co., Cleveland, Ohio.
Manufacturers of Explosives.

B. Greening Wire Co., Hamilton, Ontario, Canada.
Wire Rope.

Hadfield-Penfield Steel Co., Bucyrus, Ohio.
Manufacturer of Manganese Steel.

Harnishchfeger Corporation, 38th & National Aves., Milwaukee, Wis.
Electric Traveling Grab Bucket Cranes.

The Hayward Co., 50 Church St., New York City.
Hayward Orange Peel and Clam Shell Buckets.

The Hendrick Mfg. Co., Carbondale, Pa.
Perforated Metal Screens, Elevator Buckets.

Hercules Powder Co., Wilmington, Del.
Explosives and Blasting Supplies.

Ingersoll-Rand Company, 11 Broadway, New York City.
Air Compressors.

The Jeffrey Mfg. Co., Columbus, Ohio.
Elevating and Conveying Machinery.

Keystone Lubricating Co., Philadephia, Pa.
Lubricating Greases and Lubricating Devices.

Keystone Consolidated Publishing Co., 90 West St., New York City.

Koehring Company, Milwaukee, Wis.
Gasoline Shovels, Cranes and Draglines.

Koppel Industrial Car and Equipment Co., Koppel, Pa.
Industrial and Portable Railway Material Work.

The Loomis Machine Co., Tiffin, Ohio.
Blast Hole, Prospecting and Drilling Machinery and Tools.

The Lubriko Co., Meadow and Jackson Sts., Philadelphia, Pa.
"Lubriko Greases."

Manganese Steel Forge Co., Richmond St. and Erie Ave., Philadelphia, Pa.
"Rol-Man" Screens, Chains, Plates and Forged Products.

The Marion Steam Shovel Co., Marion, Ohio.
Power Shovels and Cranes—Steam, Gasoline and Electric.

Mid-West Locomotive Works, Cor. Spring Rd. and Alabama Ave., Cincinnati, Ohio.
Quarry Locomotives.

The Morgan Engineering Co., Alliance, Ohio.
Crushers, Overhead Traveling Cranes and Mill Machinery.

Mussens, Limited, Phillips Place Bldg., Montreal, Canada.
Rogers Timber Clamps, Mixers, Loaders.

New York Belting & Packing Co., 91 Chambers St., New York City.
Conveyors, Elevator and Transmission Belting.

Northern Explosives, Ltd., 623 Drummond Bldg., Montreal, Canada.
Blasting Supplies.

The Ohio Locomotive Crane Co., Bucyrus, Ohio.
"The Ohio Crane."

The Osgood Company, Marion, Ohio.
Power Shovels and Combinations.

Pennsylvania Crusher Co., Liberty Trust Bldg., Philadelphia, Pa.
Stone, Coal and Lime Crushers.

Pit and Quarry, Rand McNally Bldg., Chicago, Ill.
"Publishers."

Quaker City Rubber Co., Wissinoming, Philadelphia, Pa.
Belting—Hose—Packing.

Rock Products, 542 So. Dearborn St., Chicago, Ill.
"Publishers."

Robins Conveying Belt Co., 13 Park Row, New York City.
Material Handling Equipment.

The Sanderson-Cyclone Drill Co., Orrville, Ohio.
Drills, Big Blast Hole, Drilling and Fishing Tools.

Shope Brick Co., East 8th and Division Sts., Portland, Oreg.
Concrete Brick.

The Orville Simpson Co., 1230 Knowlton St., Cincinnati, Ohio.
Screens, ROTEX, level, self-cleaning, 100 to ¾" mesh.

Smith Engineering Works, 32nd and Locust Sts., Milwaukee Wis.
Rock Crushers—Gyratory, jaw and reduction.

The Spencer Construction Co., Eastern Division—Macdonald Engineering Co., Garrett Building, Baltimore, Md.
Contracting Engineers.

Symons Bros. Co., Railway Exchange Bldg., Milwaukee, Wis.
Ore, Rock and Gravel Crushers.

The Traylor Engineering & Mfg. Co., Allentown, Pa.
Crushing, Cement and Mining Machinery.

S. G. Taylor Chain Co., 140 So. Dearborn St., Chicago, Ill.
Taylor Mesaba Steam Shovel Chains.

Taylor-Wharton Iron & Steel Co., High Bridge, N. J.
TISCO Manganese Steel Castings.

The Thew Shovel Co., Lorain, Ohio.
Steam, Gasoline and Electric Shovels, Cranes, Draglines.

Trojan Powder Co., Allentown, Pa.
Explosives and Blasting Supplies.

Tredick Oil and Grease Co., Philadelphia, Pa.
Manufacturers of Petroleum Products.

Union Explosives Co., Clarksburg, W. Va.
Explosives and Blasting Supplies.

Vulcan Iron Works, Wilkes-Barre, Pa.
Steam, Gasoline, Electric Locomotives.

The W. S. Tyler Co., Cleveland, Ohio.
Woven Wire Screens and Screening Equipment.

George D. Whitcomb Co., Rochelle, Ill.
Gasoline Locomotives.

Williams Patent Crusher and Pulverizer Co., 813 Montgomery St., St. Louis, Mo.
Hammer Crushers.

G. H. Williams Co., Erie, Pa.
Cranes and Clam Shell Buckets.